Secrets to Exciting Truss Analysis

So we went from simple beams to big old complicated trusses. Luckily, we use the exact same tools that we already know like the back of our hand. Plus, we now even relish the challenge and excitement of a new truss-type problem.

First and most important step, of course, is the Free Body Diagram. Usually our truss problems will ask to find the internal forces of a certain member or members. Why do we care? Cause that way we know when it might break. After the FBD of the entire truss, we can solve for the support forces. Once we have done that, we simply draw a circle around the joint or section of the truss we want to analyze. Every where we cut through a truss member, we have to put in an internal force $\boldsymbol{P}$. Why not a $\boldsymbol{V}$ and an $\boldsymbol{M_{int}}$? Because our truss assumptions make these things go to zero. So if we draw our circle around a joint (which will be a concurrent force system), we only have 2 equations (ΣFx=0, ΣFy=0) because the ΣMp=0 doesn't do us any good. We better only cut through two unknowns. If we cut through a section of the truss, it won't be concurrent system and we can use ΣMp=0. So now we can cut through three unknown members.

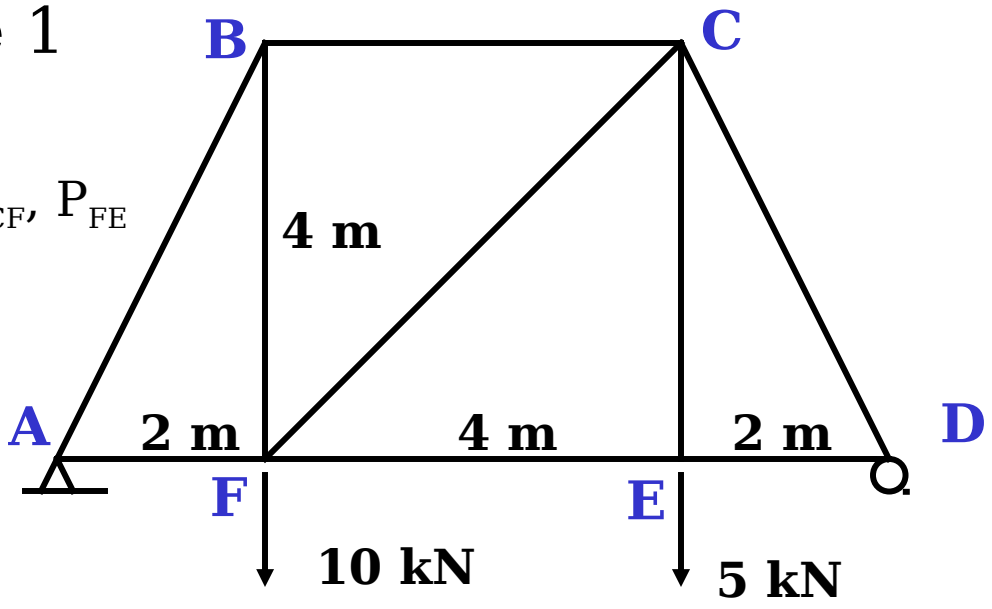
Once we solve for the internal force in a truss member, we have to decide if it is in compression or tension. Tension means it pulls away from the cut, compression means it pushes into the cut. If we are jumping from joint to joint, we have to make sure we keep track of the (T) and (C)

So steps:

1) FBD of the whole thing (might not always have to do this, but most times will)
2) Solve for reaction forces (if you have to)
3) Circle around the joint or the section that you are interested in
4) Draw in the $\boldsymbol{P}$ or internal forces where ever you made a cut

Example 1

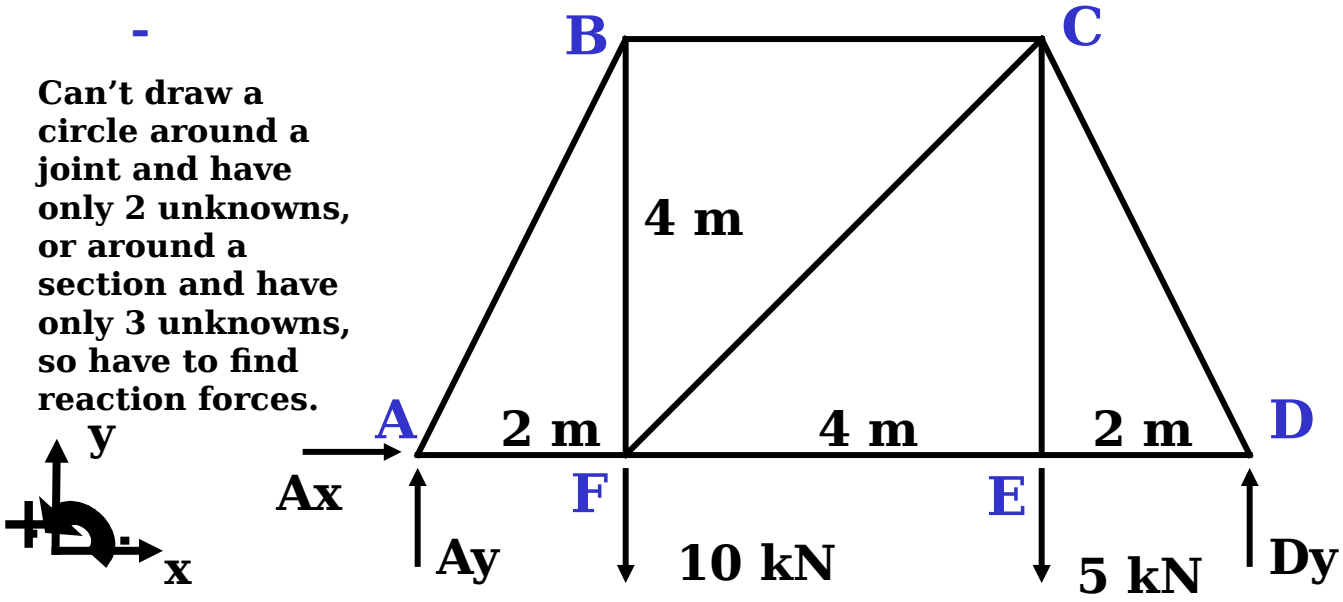
Given: FAS
Find: P_{BC}, P_{CF}, P_{FE}



Okay, go to the boards and find reaction forces, then chec

- Hit the space bar when you've worked on it and are ready to check your answer -

Can't draw a circle around a joint and have only 2 unknowns, or around a section and have only 3 unknowns, so have to find reaction forces.



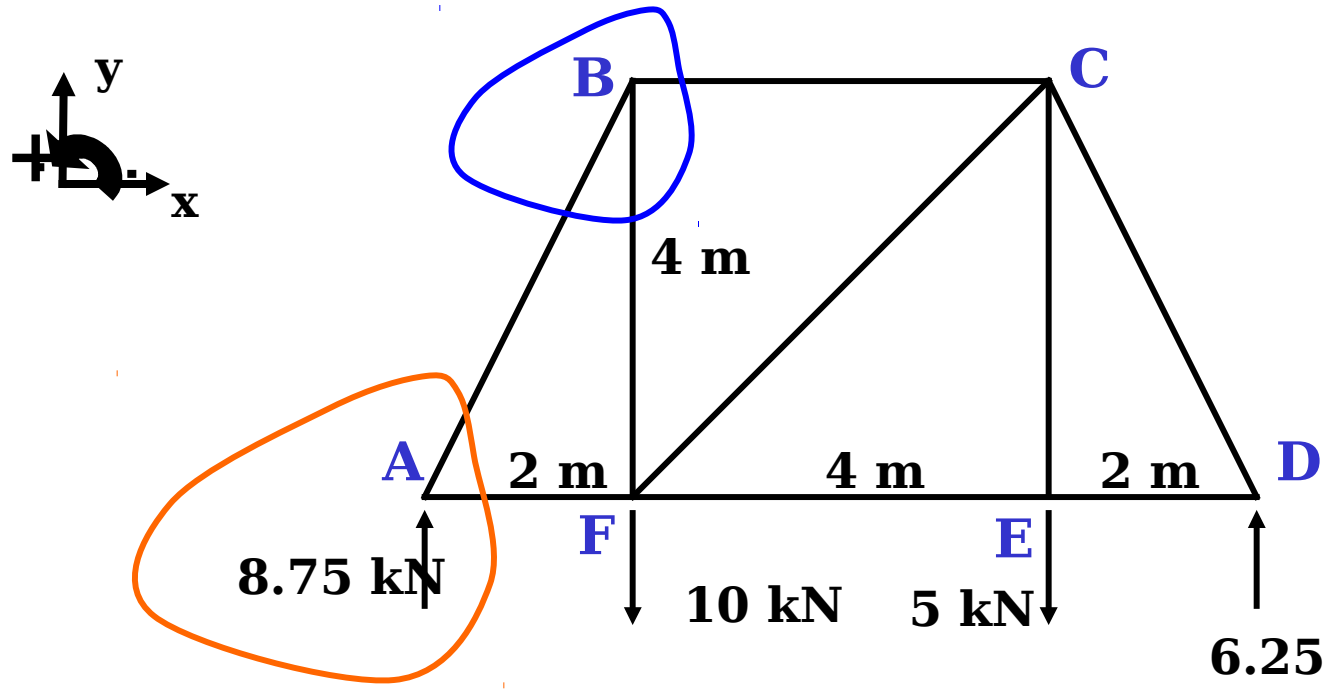
$\Sigma M_A = 0 = -(2)10 - (6)5 + (8)Dy$

$Dy = 6.25$ kN (↑) Hy is a reaction force, so is up not (T) or (C)

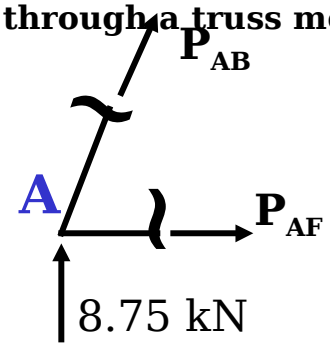
$\Sigma F_y = 0 = Ay - 10 - 5 + 6.25$

$A_y = 8.75$ kN (↑)

$\Sigma F_x = 0 = Ax$



Let's solve it first by starting at Joint A, then bounce around. {Hit space bar} Now we draw a cut FBD, including internal forces wherever we cut through a truss member. Our cut FBD then is:



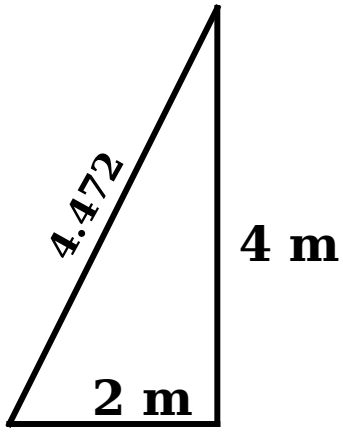
$\Sigma Fy = 0 = (4/4.472)\, P_{AB} + 8.75$

$P_{AB} = -9.78$ kN = 9.78 kN (C)

$\Sigma Fx = 0 = P_{AF} + (2/4.472)\, P_{AB}$

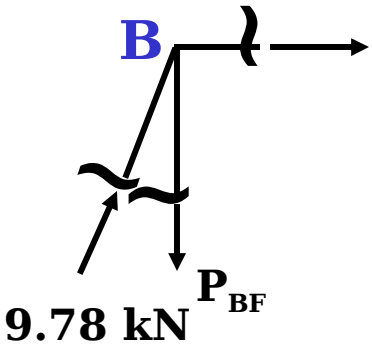
$0 = P_{AF} + (2/4.472)[-9.78]$

$P_{AF} = 4.375$ kN (T)



h= sqrt(4+16)= 4.4

Where to next? Joint F? No, that would fail (3 unknowns). {Hit space bar} Point B only has two unknowns now….

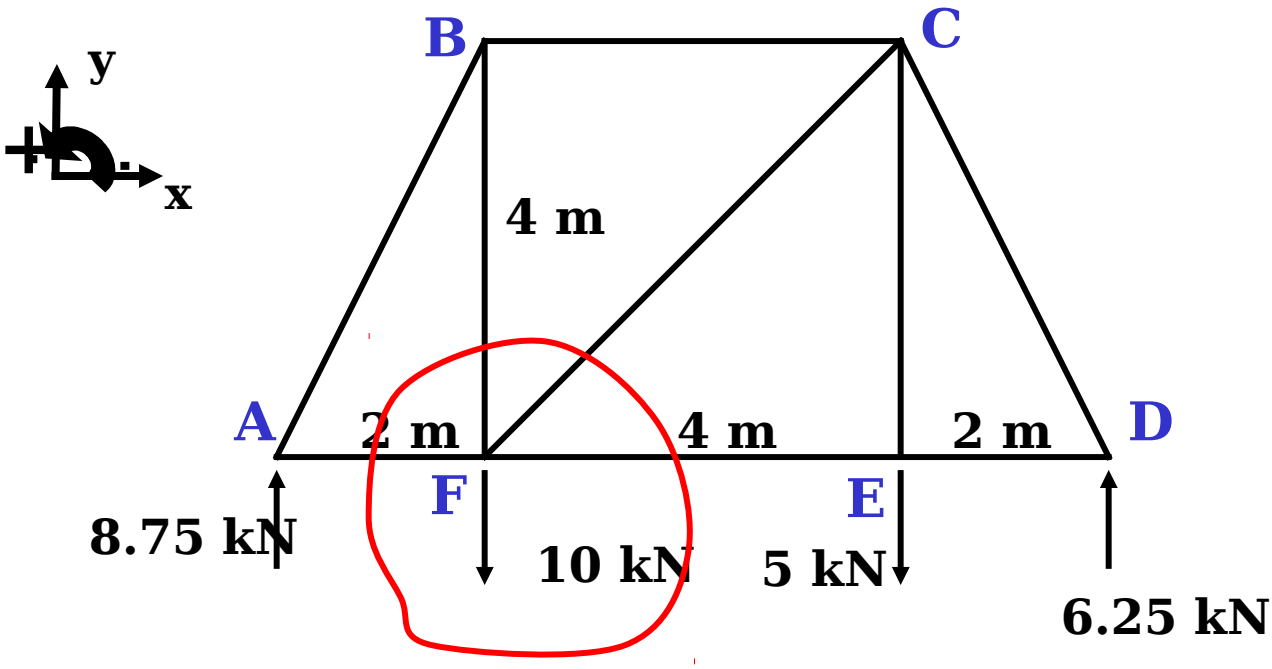


$\Sigma Fy = 0 = (4/4.472)\, 9.78 - P_{BF}$

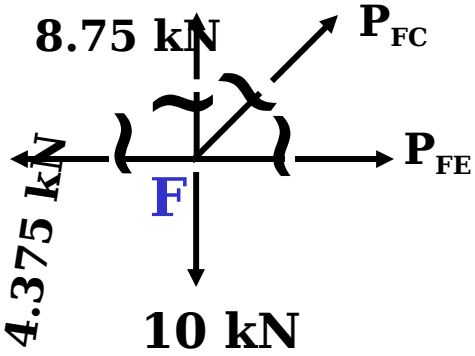
$P_{BF} = 8.75$ kN (T)

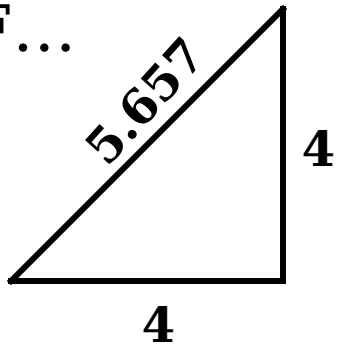
$\Sigma Fx = 0 = (2/4.472)\, 9.78 + P_{BC}$

$P_{BC} = -4.375$ kN = 4.375 kN (C)



Now I can look at joint F…





h= sqrt(16+16)= 5.65

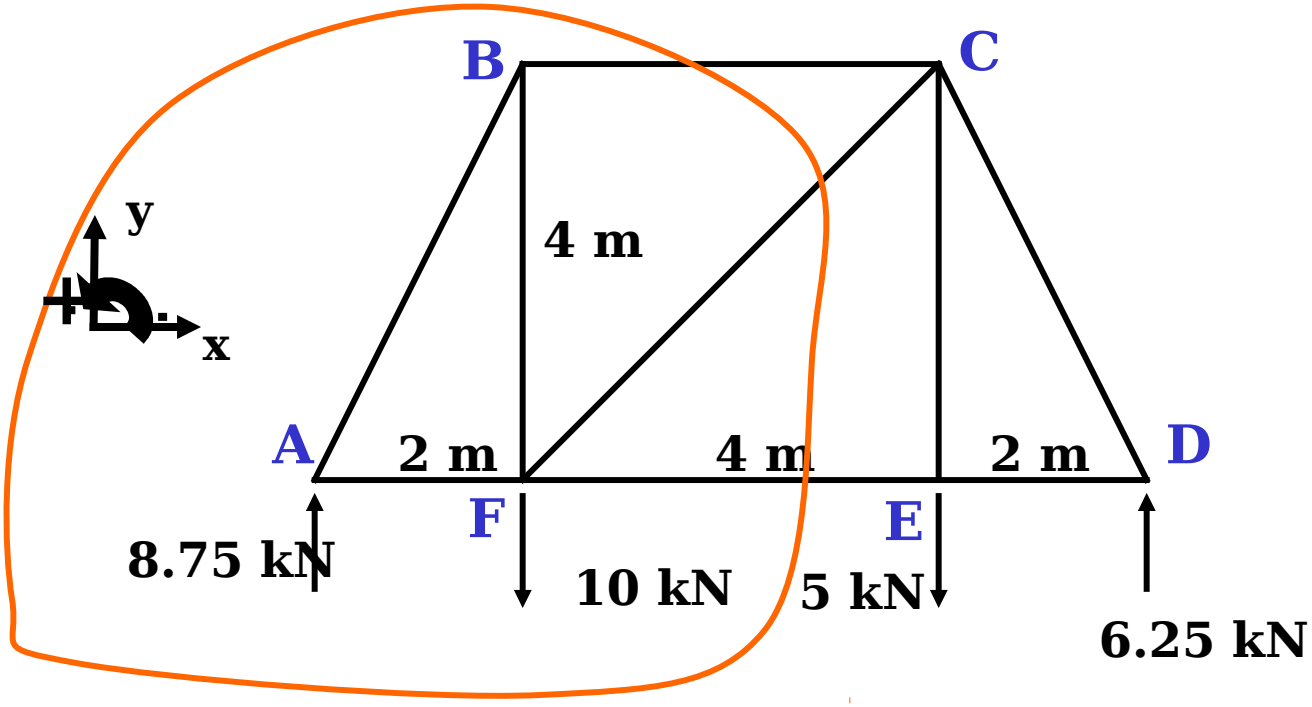
$\Sigma F_y = 0 = (4/5.657)\, P_{FC} + 8.75 - 10$

$P_{FC} = 1.77$ kN (T)

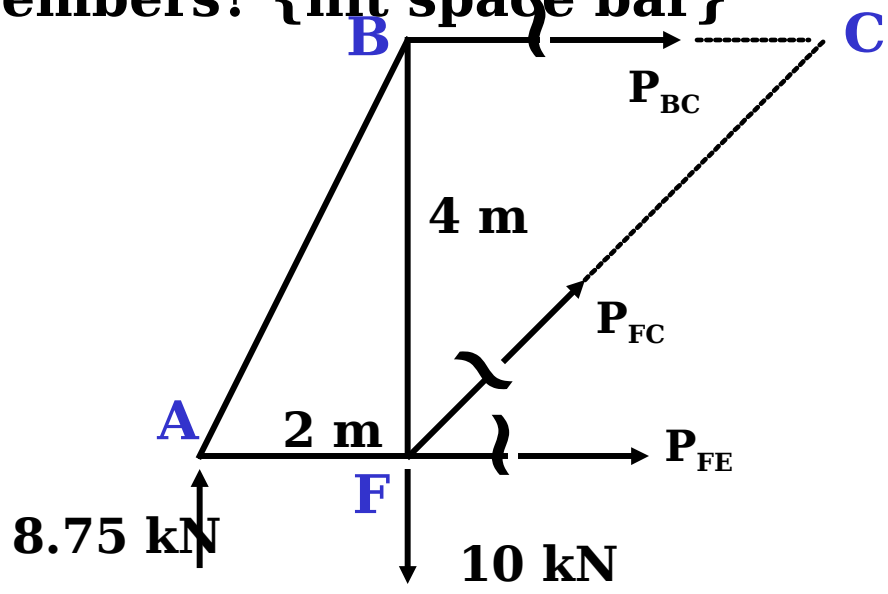
$\Sigma F_x = 0 = P_{FF} - 4.375 + (4/5.657)\, P_{FC}$

$0 = P_{FF} - 4.375 + (4/5.657)\, 1.77$

$P_{FE} = 3.125$ kN (T)



How about doing it with a big old circle that cuts through all three unknown members? {hit space bar}



$\Sigma M_F = 0 = -8.75(2) - P_{BC}(4)$ $P_{BC} = -4.375$ kN = 4.375 kN (C)

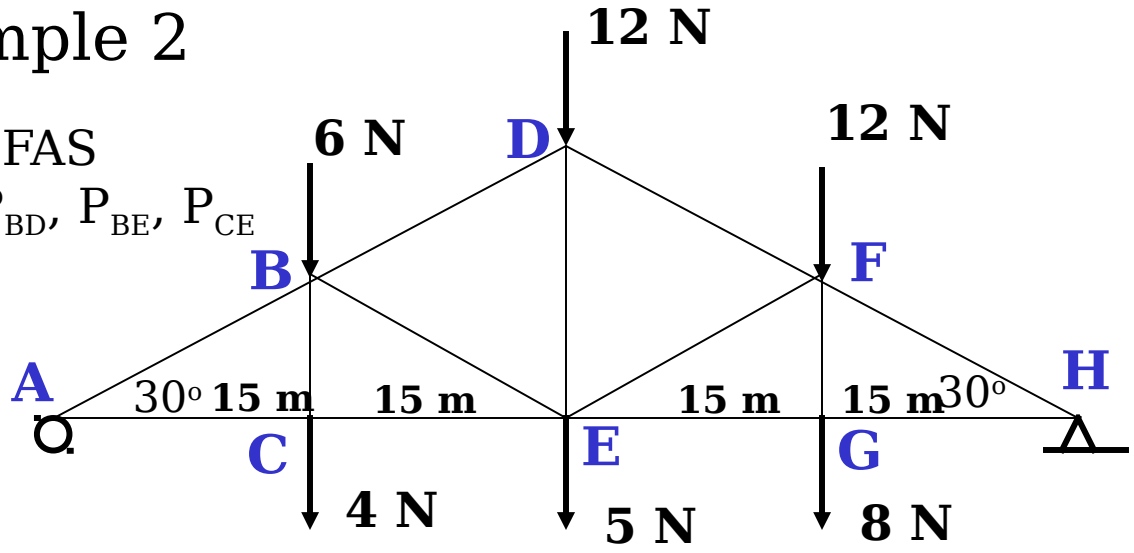
$\Sigma M_C = 0 = 4\,P_{FE} + 10(4) - 8.75(6)$ $P_{FE} = 3.125$ kN (T)

$\Sigma Fy = 0 = (4/5.657)\,P_{FC} + 8.75 - 10$ $P_{FC} = 1.77$ kN (T)

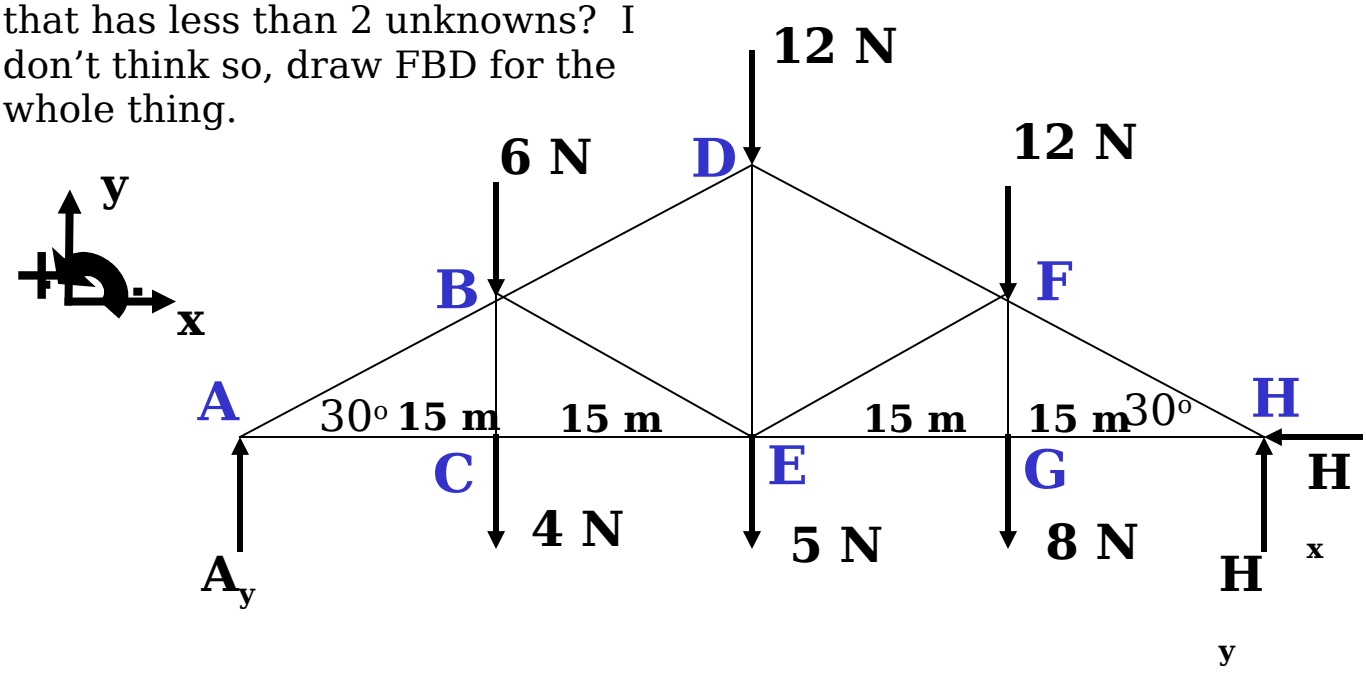
Example 2

Given: FAS

Find: P_{BD}, P_{BE}, P_{CE}



Can we draw an FBD around a joint that has less than 2 unknowns? I don't think so, draw FBD for the whole thing.

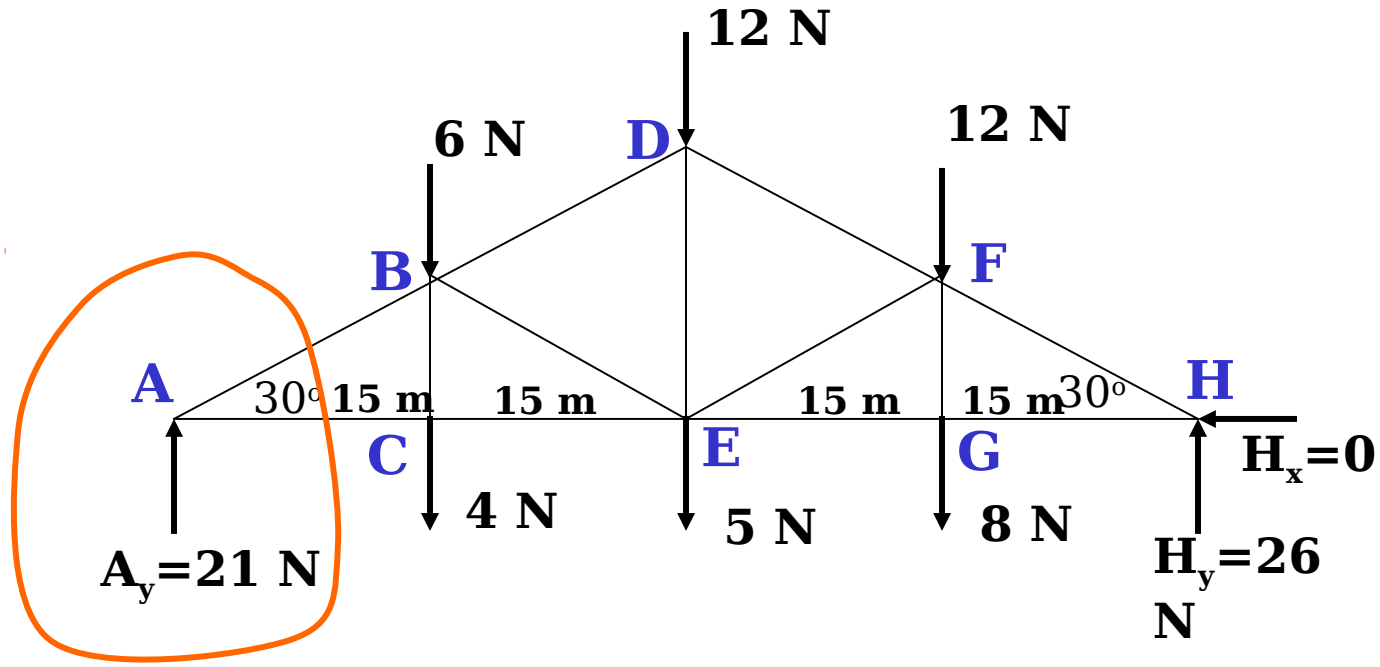


$\Sigma M_A = 0 = -(6)15 - (4)15 - (12)30 - (5)30 - (12)45 - (8)45 + (Hy)60$

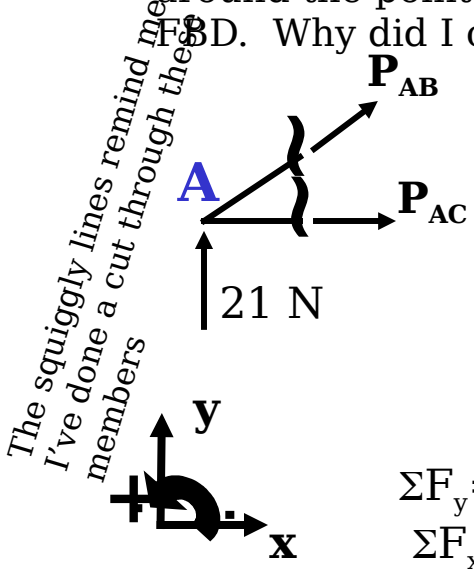
$Hy = 26$ N (↑) Hy is a reaction force, so is up not (T) or (C)

$\Sigma F_y = 0 = 26 + 6 + 4 + 12 + 5 + 12 + 8 + A_y$

$A_y = 21$ N (↑)



So now we have the reaction forces, we can do a cut FBD around the point A (hit the space bar). Now draw the new FBD. Why did I choose point A?



Because it only has two unknowns, and since it's a concurrent force system, ΣM=0 just doesn't help me much.

We've done a cut, so that means I have to include the internal forces – which also means I have (T) or (C) in my final answer.

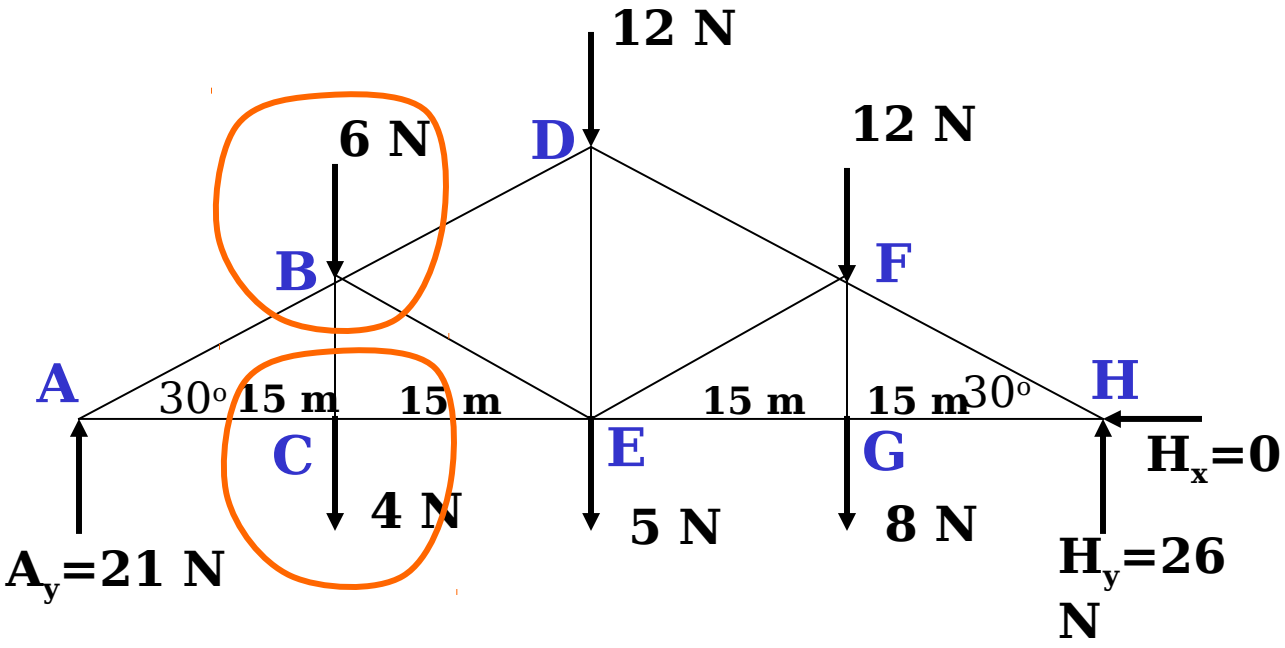
$\Sigma F_y = 0 = 21 + P_{AB} \sin 30 \quad P_{AB} = -42 \text{ N} = 42 \text{ N (C}$

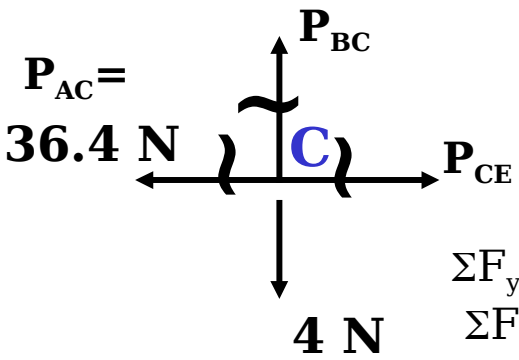
$\Sigma F_x = 0 = P_{AC} + P_{AB} \cos 30 = P_{AC} + (-42)$

$P_{AC} = 36.4 \text{ N (T)}$

When I do $\Sigma F_x = 0$, my FBD tells me to put P_{AB} going up to the right (or +). But from $\Sigma F_y = 0$ I found out it goes down and to the left, so I just have to plug in the –42 N in my $\Sigma F_y = 0$ equation.

So, where's another joint with two or less unknowns? How



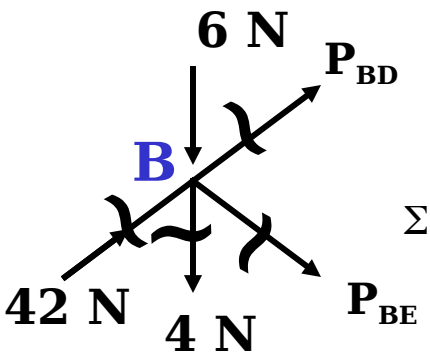


We found that P_{AC} was in tension, so we draw it out of the cut on the FBD and we know it is 36.4 N. Only two unknowns left.

$\Sigma F_y = 0 = -4 + P_{BC}$ $\quad P_{BC} = 4$ N (T)

$\Sigma F_x = 0 = -36.4 + P_{CE}$ $\quad P_{CE} = 36.4$ N (T)

Let's hop on over to point B (hit the space bar) – to



Lots of stuff going on here. We realize that PBC was just found to be 4 N (T), so we draw it out of the cut. We also know that PAB was 42 N (C), so it goes into the cut. Don't forget that 6 N applied force up top!

$\Sigma F_x = 0 = 42 \cos 30 + P_{BD} \cos 30 + P_{BE} \cos 30$

$P_{BD} + P_{BE} = -42$

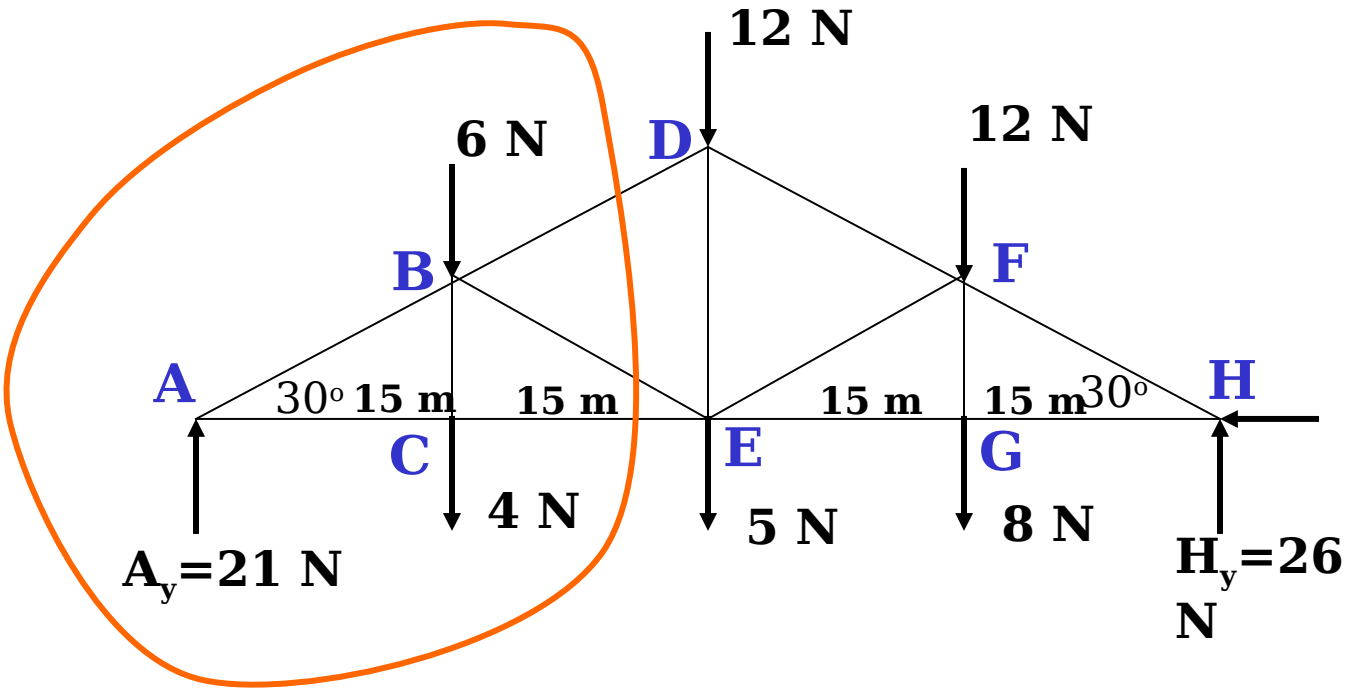
$\Sigma F_y = 0 = 42 \sin 30 + P_{BD} \sin 30 + -P_{BE} \sin 3$

$P_{BD} = -22 + P_{BE}$ Plug P_{BD} into top e

$2 P_{BE} - 22 = -42$

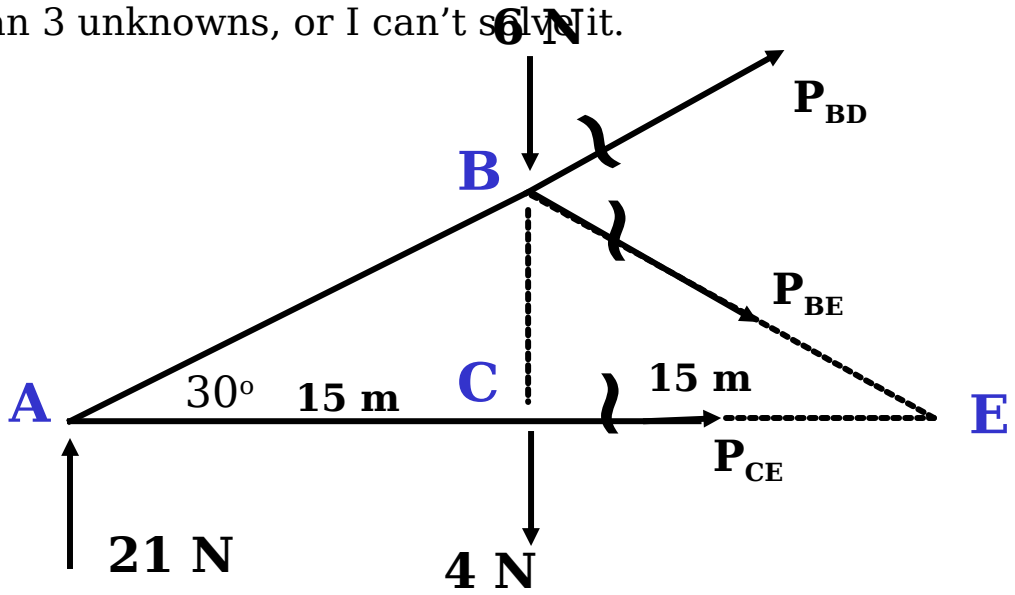
$P_{BE} = -10$ N $= 10$ N (C)

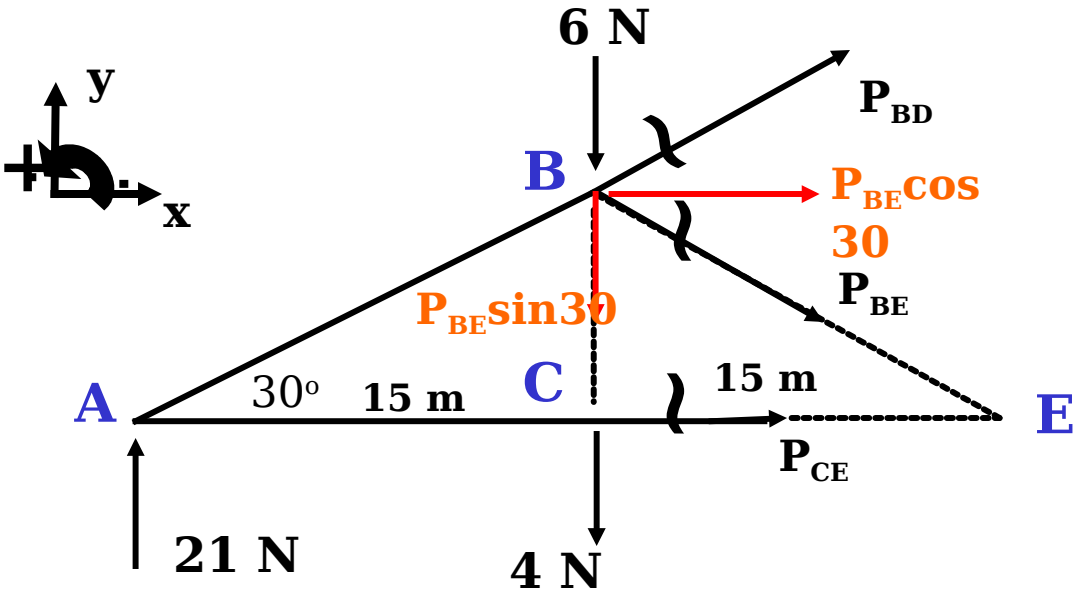
$P_{BD} = -32$ N $= 32$ N (C)



Can we do a different cut, one that isn't just around a point, that would allow us to find forces in BD, BE, and CE? Well I bet if you hit the space bar you can.

Now for the cut FBD it is important to remember a few things. We are only concerned now about the internal forces where we have made a cut – P_{AB} and P_{AC} now have nothing to do with the problem. The body we are isolating is the left part of the truss as shown below. We have to include all of the external forces in the circle, and all internal forces where the circle cuts through a truss member. I have to make sure the circle doesn't cut through more than 3 unknowns, or I can't solve it.





Looks pretty familiar to other problems, use the 3 equilibrium equations. Looks like the easiest thing to do is start by summing moments about point B – then the only unknown will be P_{CE}. Uh, oh. How do I find that perpendicular distance from point B to the force P_{CE}? Well, using your astute powers of trigonometry, we look at that triangle ABD and note that tan 30 = (y/15), so therefore y= 15 tan 30.

$\Sigma M_B = 0 = -21(15) + P_{CE}\ (15 \tan 30)$ $P_{CE} = 36.4$ N (T)

All right. Same as we got before. Next part is a little harder. If we sum forces, we'll have to solve two simultaneous equations. That's a pain in my truss. Let's sum moments about point A instead, since P_{BD} passes right through it. First we'll have to break P_{BE} into components (hit space bar). If you want the components to go away, hit the space bar again.

$\Sigma M_A = 0 = -4(15) - 6(15) - P_{BE}\ \sin 30\ (15) - P_{BE} \cos 30\ (15 \tan 30)$ $P_{BE}\ [\sin 30\ (15) + \cos 30\ (15 \tan 30)\ ] = -150$

$P_{BE} = -10$ N = 10 N (C)

$\Sigma Fx = 0 = P_{CE} + P_{BE} \cos 30 + P_{BD} \cos 30 = 36.4 + (-10) \cos 30 + P_{BD} \cos 30$

$P_{BD} = -27.7 / \cos 30 = -32$ N

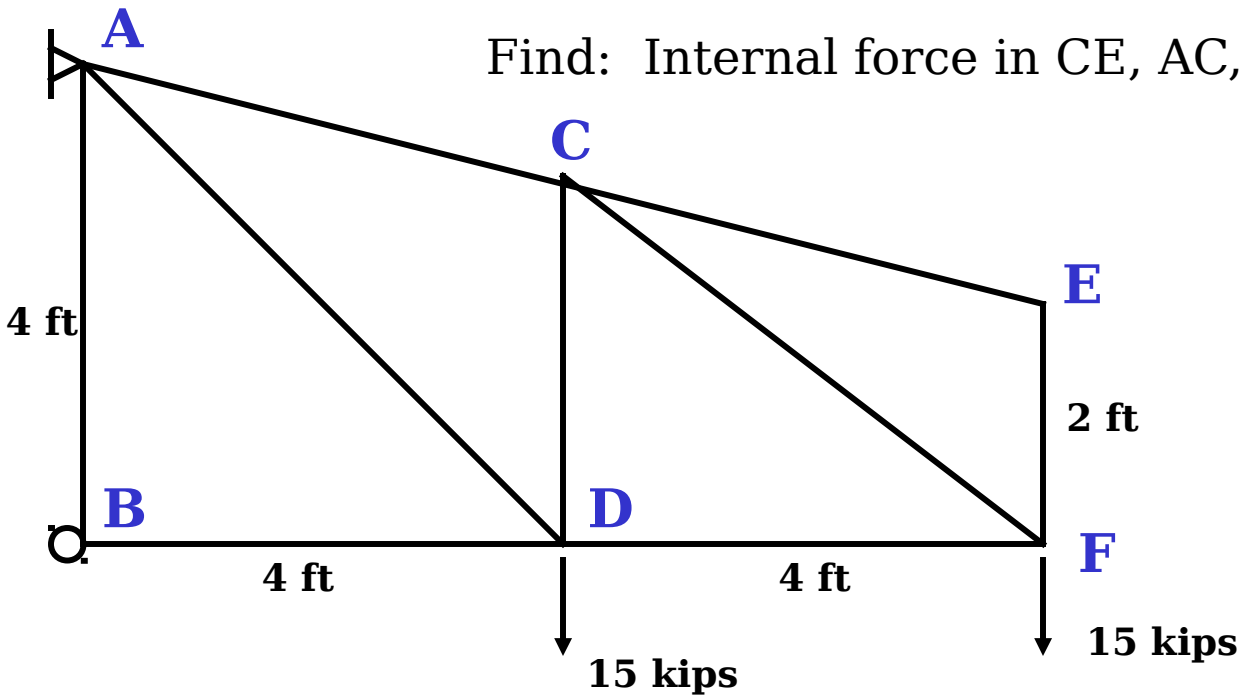
$P_{BD} = 32$ N (C)

To check

$\Sigma Fy = 0 =$ $-P_{BE} \sin 30 + P_{BD} \sin 30 - 6 - 4 + 21 =$

A few practice problems for you to work – email me you answers and I'll let you know how you did.

Find: Internal force in CE, AC, DF



Given: All truss members are 5 ft long
Find: Internal force in DE, BC